

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

**Birth weight and growth of New Zealand
Thoroughbred foals**

A thesis presented in partial fulfilment of the requirements for the degree of

Master of Veterinary Studies

at Massey University, Turitea, Palmerston North,
New Zealand

Luciana de Freitas Aiex

2008

Abstract

The success of the New Zealand Thoroughbred horse industry is highly dependant on the production of good foals. The birth weight of the foal, and its weaning weight, is closely associated with maternal factors, such as age, parity, size, and nutrition. Age is associated with endometrosis and limited placentation, which leads to a reduction in foal birth weight. Multiparous mares tend to produce larger foals than primiparous mares because of the priming effect that a first pregnancy has on the uterus.

Nutrition affects the size of the mare, which is positively correlated with foal birth weight. The size of the mare is positively correlated with birth size of the foal, and the birth weight of the foal is positively correlated with the mass, gross area and volume of the allantochorion, and the total area of foetomaternal contact. The information available on the maternal effects on foal birth weight is limited. This study attempts to improve our understanding of this relationship by examining data collected from New Zealand Thoroughbred mares, which are held on pasture throughout the year and may receive little supplementary feed during pregnancy.

Data were collected from 49 New Zealand Thoroughbred mares and their foals during the 2004 foaling season. Analyses were conducted to determine whether the age, parity, body condition score, weight pre- and post-partum, and height of the mare, the length of gestation and the allantochorion weight and volume were associated with foal sex ratio ($n = 49$), foal wet birth weight ($n = 27$), day 1 weight ($n = 49$), and foal height ($n = 49$). The daily growth of a subgroup of 15 foals in their first two weeks of life was monitored. In addition, age and parity data was collected via the online Thoroughbred Studbook from 492 mares that were bred to one of the Waikato Stud stallions in the 2001 breeding season.

The mean age of mares was 10.8 ± 0.8 years for the Newmarket Lodge population and 11.0 ± 0.2 years for the Waikato Stud population; the mean parity of mares was 4.5 ± 0.4 for the Newmarket Lodge population and 5.9 ± 0.2 years for the Waikato Stud population; and the mean length of gestation was 355.67 ± 1.26 days. The age and parity of the mare and the sex of the foetus had no significant effect on the length of

gestation. Primiparous mares had significantly lighter and lower foals than multiparous mares, independently of the age of the mare. The mean wet birth weight of foals was 54.6 ± 1.1 kg and the mean day 1 weight was 55.7 ± 0.8 kg. The range of foal birth weights was from 41.0 to 66.5 kg. The sex of the foal did not significantly affect its wet birth weight and day 1 weight. The mean wet birth weight was 54.1 ± 2.1 for a filly, and 55.0 ± 1.3 for a colt. The mean day 1 weight was 55.2 ± 1.4 for a filly and 56.2 ± 1.1 for a colt. The relationship between the wet weight of the foal and its day 1 weight was highly significant.

Mare age and parity affected the weight and volume of the allantochorion. The allantochorions of primiparous and multiparous mares aged 16 years and over were lighter and had lower volumes than those of multiparous mares aged five to 15 years. There was no difference in the weight and volume of the allantochorions of primiparous mares and multiparous mares aged 16 years and over. The mean weight of the allantochorion was 3.68 ± 0.09 kg, and the mean volume was 2.86 ± 0.07 litres. The weight and volume of the allantochorion were significantly associated with the wet birth weight and day 1 weight of the foal. Moreover, the weight of the mare pre- and post-partum significantly affected the wet birth weight, the day 1 weight, and the height of the foal. Mares lost an average of 80.9 kg liveweight with the foaling process.

Foals lost on average 1.17 ± 0.94 kg between the wet birth weight and day 1 weight measurements. Seventy percent of foals lost weight between these measurements. The average daily weight gain of foals from day 2 to day 14 of life was 1.71 ± 0.11 kg. The average weight gain of foals was 25.05 ± 1.02 kg in the first 14 days of life. The mean height of foals at birth was 1.028 ± 0.008 m and they grew on average 0.062 ± 0.005 m to reach a mean height of 1.087 ± 0.005 m at two weeks of age. The average daily height increase from day 1 to day 14 was 0.004 ± 0.002 m. There was no significant influence of the sex of the foal on the weight gain and height increase from day 1 to day 14, although the mean wet birth weight, day 1 weight and day 14 weight of colts is slightly higher than that of fillies.

Maternal factors influence the birth size of the NZTB foal born to mares kept on pasture. The weight of the mare is closely associated with the size of the allantochorion, which is significantly associated with the birth weight of the foal. Primiparous and older

mares (≥ 16 years) produce smaller foals than multiparous mares younger than 16 years. Foals lose weight in the first 24 hours after birth. This early neonatal weight loss probably occurs because of drying off. The sex of the foal did not affect the length of gestation, and it did not influence the birth weight of the foal and its daily growth in the first two weeks post-partum. The information in this study has not been previously reported for horses in New Zealand.

Acknowledgements

This thesis would not have been realized without the support of numerous people. I am sincerely grateful to my supervisor, Associate Professor Kevin Stafford, for guiding and encouraging me through the final stages of the thesis. I would also like to express my appreciation to my co-supervisor Elwyn Firth for his understanding, and dedication to precise scientific research. And to my original supervisor, Dr. Erica Gee, your support and understanding were greatly appreciated. The work of the aforementioned people has undoubtedly shaped this thesis. I would also like to extend my gratitude to Sam Peterson for giving me opportunities to expand my knowledge and gain skills by working in other research projects and teaching lab classes.

Throughout my research, I was fortunate to have Allain Scott to count on. I would also like to thank Liz Gillespie, Chris Rogers, Bruce Cann, Neil Ward, Peter Wildbore, Dean Burnham, Andrew Rowatt, Hilary Shaw for the countless hours of technical assistance. Many thanks also go to Alasdair Noble, Vera Costa, and Gina deNicolò for sharing your statistical knowledge and helping me with the daunting task of analysing my data.

This thesis would not be possible without the staff at Newmarket Lodge - Libby, Amy, Brown, Lance and Mark. I am extremely grateful for your help and support. I would also like to thank Dr. John O'Brien for allowing me to collect data from the animals on his property and helping me weigh foals at all hours of the night. In addition, I would like to thank David O'Brien, Marieke, and my dear friends Manon and Megan for helping me to weigh the foals.

I gratefully acknowledge the financial support from Equine Research New Zealand, the IVABS funding for postgraduate research and the William Massey Memorial Trust Millar Buchanan Postgraduate Scholarship.

To my precious friends Julia, Rossana, Dani, Zachinho, Fede, Hannah, Anita, Manon, Megan, Marcela, Anja, Sandra, Richard, Alex, Annemarie, Eduardo, and Hamish, thank you for your constant encouragement and support, for the laughter and for being there in the times of need.

I wish to thank my wonderful family for their support, encouragement, and strength. Especially my mother, for her love and courage; my brother, for his sense of humour and loyalty; and my sister, for her pragmatism and uncompromising ideology. In addition, I would like to thank Shawn for his advice, incentive and patience, his ability to make things seem simpler and for being there for me every single day.

Table of Contents

ABSTRACT	i
ACKNOWLEDGMENTS	iv
TABLE OF CONTENTS	vi
LIST OF TABLES	x
LIST OF FIGURES	xi
ABBREVIATIONS	xiv

CHAPTER 1 – Introduction

1.1 Introduction	1
------------------	---

CHAPTER 2 – Literature Review

2.1 The New Zealand Thoroughbred breeding industry	3
2.1.1 Importance of reproductive performance to the New Zealand Thoroughbred Industry	4
2.2 Maternal influences on foal birth weight	5
2.2.1 Age	5
2.2.2 Parity	7
2.2.3 Size	8
2.3 Nutrition of the broodmare and foal	12
2.3.1 Nutrient requirements	12
2.3.2 Nutrients from pasture	14
2.3.3 Lactation	16

2.3.4	Foal nutrition	18
2.4	Development of the placenta	19
2.4.1	Placenta structure and physiology	19
2.4.2	Placenta maturation and release of membranes	22
2.5	Foetal and neonatal growth and development	23
2.5.1	Growth	23
2.5.2	Factors affecting foetal development	24
2.5.2.1	Twins	24
2.5.2.2	Placentitis	25
2.6	Thesis objectives	26

CHAPTER 3 – Materials and Methods

3.1	Waikato Stud Population	28
3.1.1	Distribution of mare age and parity, and foal sex ratio	28
3.2	Newmarket Lodge Population	28
3.2.1	Experimental site	28
3.2.1.1	Location and climate	28
3.2.1.2	Pasture	29
3.2.2	Experimental animals	29
3.2.3	Weighing scales	30
3.2.3.1	Description of the mare and foal platforms	30
3.2.3.2	Description of the placenta weighing scales	31
3.2.3.3	Validation of the foal platform	31
3.2.3.4	Validation of the mare platform	32
3.2.3.5	Validation of the placenta weighing scales	32

3.2.4	Data collection procedures	32
3.2.4.1	Age and parity of the mare	32
3.2.4.2	Body condition score of the mare	33
3.2.4.3	Pre-foaling weight of the mare	34
3.2.4.4	Post-partum weight and height of the mare	35
3.2.4.5	Foal birth weight data	36
3.2.4.5.1	Foaling procedure	36
3.2.4.5.2	Day 0 birth weight data collection	36
3.2.4.5.3	Day 1 birth weight and height data collection	37
3.2.4.6	Length of gestation data	38
3.2.4.7	Placenta size data	38
3.2.4.7.1	Day 0 weight	38
3.2.4.7.2	Volume	39
3.2.4.7.2.1	Method 1 – Weight of water displaced method	39
3.2.4.7.2.2	Method 2 – Water displacement method	40
3.2.4.8	Longitudinal study – foal growth	41
3.3	Statistical analysis	41

CHAPTER 4 - Results

4.1	Limitations in weight measurements	43
4.2	Distribution of mare age and parity, and foal sex ratio	44
4.2.1	Waikato Stud sample population	44
4.2.2	Newmarket Lodge population	46
4.3	Effect of mare age and parity on length of gestation, placenta size, and foal sex ratio and birth size	49

4.4	Effect of mare size on foal birth weight, height, and sex	54
4.5	Effect of allantochorion size on the birth weight of the foal	59
4.6	Effect of the sex of the foal on the length of gestation and foal birth weight	63
4.7	Foal birth weight and growth	64
4.7.1	Foal birth weight	64
4.7.2	Foal growth	66
4.8	Mare weight change two weeks post-partum	71

CHAPTER 5 – Discussion

5.1	Distribution of mare age and parity, and foal sex ratio of the NZTB study population	73
5.2	Length of gestation, foal sex and the birth weight of the foal	75
5.3	The effect of mare size on foal birth size	76
5.4	The effect of placenta size on foal birth size	78
5.5	Foal growth from birth to two weeks of life	80
5.6	Limitations	82
5.6.1	Assessing the weight of foals and mares	82
5.6.2	Assessing the weight, area and volume of the placenta	84
5.7	Conclusion	85
	REFERENCES	87

LIST OF TABLES

Table 2.1: Mean \pm SEM maternal, foetal and placental parameters measured in 11 mares at the end of their first and second parities	8
Table 2.2: Mean energy and protein contents of pastures for horses in New Zealand	14
Table 4.1: A comparison of the sex ratio between the Newmarket Lodge and NZTB studbook populations according to the parity of the mare	48
Table 4.2: The mean length of gestation of mares in the Newmarket Lodge population according to age and parity	49
Table 4.3: The number and proportion of colts and fillies according to the age and parity of the mare in the Newmarket Lodge population	51
Table 4.4: The wet weight and day 1 weight of the foal according to the age and parity of the mare in the Newmarket Lodge population	51
Table 4.5: The mean foal height at birth according to the age and parity of mares	53
Table 4.6: The weight and volume of the allantochorion according to the age and parity of the mare	53
Table 4.7: Mean size of mares in the Newmarket Lodge population	54
Table 4.8: The mean foal birth weight and length of gestation according to the sex of the foal	63
Table 4.9: The mean weight and height of foals at specific ages during the longitudinal study	67

LIST OF FIGURES

- Figure 2.1:** Diagrammatic representation of the essential architecture of the endometrium of the mare in (a) a healthy, fertile young animal and (b) an aged mare exhibiting the degenerative changes of endometrosis (from Allen and Stewart, 2001) 6
- Figure 2.2:** Diagrammatic representation of the structure and vascularization of the mature microcotyledons in the equine placenta (reproduced from Steven and Samuel, 1975) 20
- Figure 3.1:** Foal platform (left) and mare platform (right) used in the experiment 30
- Figure 3.2:** Counter beam (balance) scale (Unknown, 2006) 31
- Figure 3.3:** Set up of method 1 to measure the volume of the allantochorion 40
- Figure 4.1:** Change in weight recorded daily for the standard weights used during the experiment in both the mare platform and the foal platform. 43
- Figure 4.2:** The age distribution of Waikato Stud sample population mares (data obtained from some mares bred to Waikato Stud sires – Centaine, Danasinga, Pins, and O’Reilly – in the 2002 breeding season) 44
- Figure 4.3:** Parity distribution of Waikato Stud sample population mares (data obtained from some mares bred to Waikato Stud sires – Centaine, Danasinga, Pins, and O’Reilly – in the 2002 breeding season) 45
- Figure 4.5:** Age distribution of Newmarket Lodge mares 47
- Figure 4.6:** Parity distribution of Newmarket Lodge mares 47
- Figure 4.7:** The correlation between age and parity of mares in the Newmarket Lodge population 48
- Figure 4.8:** The relationship between length of gestation and the wet birth weight of the foal 50
- Figure 4.9:** The relationship between length of gestation and the day 1 weight of the foal 50

Figure 4.10: Mean (\pm SEM) wet weight and day 1 weight of foals according to the parity of the mare	52
Figure 4.11: The relationship between mare pre-foaling weight and foal wet birth weight	55
Figure 4.12: The relationship between mare weight pre-foaling and foal day 1 weight	56
Figure 4.13: The relationship between mare weight pre-foaling and foal height	56
Figure 4.14: The relationship between mare weight post-foaling and foal wet birth weight	57
Figure 4.15: The relationship between mare weight post-foaling and foal day 1 weight	57
Figure 4.16: The relationship between mare weight post-foaling and foal height	58
Figure 4.17: The relationship between mare height and the day 1 weight of the foal	58
Figure 4.18: The correlation between the weight of the allantochorion on day 0 and day 1	60
Figure 4.19: The relationship between the weight of the allantochorion and the wet weight of the foal	60
Figure 4.20: The relationship between the weight of the allantochorion and the day 1 weight of the foal	61
Figure 4.21: The relationship between the volume of the allantochorion and the wet birth weight of the foal	62
Figure 4.22: The relationship between the volume of the allantochorion and the day 1 weight of the foal	62
Figure 4.23: The relationship between foal wet weight and day 1 weight	64
Figure 4.24: The time difference between the measurements of wet birth weight and day 1 weight of the foal does not affect the weight difference between wet birth weight and day 1 weight	65
Figure 4.25: The mean weight of foals from birth to 14 days of age	66

Figure 4.26: The changes in foal weight in the first 3 days of life	68
Figure 4.27: The daily weight change of individual foals and the average daily weight change in the first two weeks of life	69
Figure 4.28: The average daily weight change of foals from birth to 14 days of age	69
Figure 4.29: The average daily height of foals in the Newmarket Lodge population from birth to two weeks of age	70
Figure 4.30: The average daily height increase of foals in the Newmarket Lodge population from birth to two weeks of age	70
Figure 4.31: The daily weight of individual mares and the average daily weight of mares in the first two weeks post-foaling	71
Figure 4.32: The average daily weight change of mares in the first two weeks post-foaling	72

ABBREVIATIONS

AC	Allantochorion
cm²	centimeter square
cm²/cm³	centimeter square per centimeter cubed (unit of area per unit volume)
CP	Crude protein
DE	Digestible energy
Foal day 1 weight	Foal weight on the morning after birth (within 8 to 12 hours of birth)
g/kg DM	gram of protein per kilogram of dry matter
IgG	Immunoglobulin G
IUGR	Intrauterine growth retardation
Kcal	kilocalorie
Kg	Kilogram
Kg/d	Kilogram per day
l	litre
MJ	Megajoule
MJ DE/day	Megajoule of digestible energy per day
µm⁻¹	micrometer to the power of negative one (or µm ² /µm ³ , unit of microcotyledon surface density)
NRC	National Research Council
NZTB	New Zealand Thoroughbred
NZTR	New Zealand Thoroughbred Racing
P	pony
SEM	Standard error of the mean
TB	Thoroughbred

Wet birth weight Foal birth weight immediately after birth